Remarks

Claims 1-41 remain pending.

As previously amended, the independent claims specify that the adapting of the encoding of the frame occurs when the frame is a still frame (as defined in the independent claims and discussed further below) which is being non-intra encoded. When the frame is being non-intra encoded, the adapting includes adjusting the at least one controllable parameter employed in encoding the still frame to disable motion estimation and limit motion compensation. This disabling of the motion estimation and limiting of motion compensation for the non-intra encoded frame is such as to minimize after decoding thereof, visually perceptible pulsation artifacts between still frames of a sequence of still frames.

None of the applied art, individually or in combination, appears to teach, suggest or imply adapting non-intra encoding of a still frame to adjust at least one controllable parameter employed in encoding the still frame to disable motion estimation and limit motion compensation. In non-intra coding, both motion estimation and motion compensation are conventionally employed. This aspect of applicants' amended independent claims is discussed further below with reference to Pearlstein et al.

Beginning with the Background of the Invention, applicants discuss the problem addressed by the present invention. In particular, when input video is constant, i.e., comprises a sequence of still image frames (i.e., content identical and unvarying to content of a preceding frame), slight variations in the amount of detail in a macroblock of a current frame compared to the same macroblock of a prior frame or a next frame in the series of still image frames can create fluctuation in encoded luminance and/or chrominance data, which can appear as movement between frames when decoded notwithstanding that the initial frames actually comprise a series or sequence of still image frames. For instance, variation in chrominance data from a prior frame to a current frame can create differences in shade of the same color of the encoded and decoded frame. These differences in color shade effectively create "pulsation artifacts" which can cause a series of still image pictures to come alive and no longer resemble the original input video. (See column 3, lines 12-26).

Thus, a general goal of the present invention is to provide an encoding technique which minimizes or even eliminates perceptible picture pulsation in a sequence of MPEG encoded still image frames or partial still frames. (Column 5, lines 28-32).

Adaptive quantization can be used to control the amount of data generated so that an average amount of data is output by the encoder and so that this average will match a specified bit rate, thereby achieving an overall constant bit rate. Since this compression has adaptive capabilities, there is a possibility that macroblocks in a "still frame" (defined below) can change slightly from corresponding macroblocks in a prior or reference "still frame". This is partially due to the type of motion estimation employed. For example, hierarchical motion estimation is often used for MPEG encoding in order to save circuitry, enhance performance and reduce memory bandwidth. Hierarchical motion estimation, however, does not rely on a full motion estimation search pixel by pixel. Rather, a scaled down picture size is employed by grouping pixels together (for example, four pixels) into a single modified pixel value, which results in loss of accuracy when motion estimation is performed. This inaccuracy can create small errors, which in the case of motion video is acceptable because the difference data (i.e., the prediction error) is forwarded to the decoder for use in recreating the original picture. However, in the case of still image pictures, these inaccuracies are manifested as pulsation artifacts due to differences in encoded shading and color between adjacent still image frames, which cause the still picture to appear to be moving.

Based on this observation, applicants have conceived of the present invention to enhance MPEG encoding of a still or partially still picture sequence and minimize or even eliminate pulsation artifacts between decoded frames in a sequence of still video.

Two considerations are important to preventing pulsation between still image pictures. One requirement is that the same coding type be employed from still image picture to still image picture, and the second is that a comparable level of quantization be maintained for the same macroblock from still picture to still picture. However, these coding options can only be applied

when a picture is first determined to be a still picture. (See page 15, line 3 – page 16, line 26 of the Specification).

To summarize, the difference in quantization levels between corresponding macroblocks in a reference still picture and a subsequent still picture may appear after compression (i.e., encoding) and decompression (i.e., decoding) as a difference. For example, in color shade which can result in the appearance of movement between still pictures in the sequence. This movement is referred to herein as "pulsation artifacts" (see page 28, lines 4-12 of the Specification). Applicants have discovered that pulsation artifacts can exist between pictures having identical content from one frame to another. Because normal rate control causes bit allocations to differ by picture type (for example, I pictures may be allocated 4X as many bits as P pictures, and 8X as many bits as B pictures), constant bit rate encoding allows for quantization (compression) variations between pictures and between macroblocks within pictures. When identical content pictures are encoded at different quantization levels the lossy nature of the MPEG compression algorithm causes the decoded pictures to differ slightly from the original. In such a sequence, this difference manifests itself as pulsation artifacts, that is, pictures that seem to move slightly even though there is no motion from frame to frame in the pre-encoded sequence of still frames. MPEG allows for maintaining the quantization level at a constant value, but then the bit rate must be variable (VBR).

The Office Action cites Reininger et al. (U.S. Patent No. 5,426,463) in view of Astle (U.S. Patent No. 5,751,861) and Pearlstein et al. (U.S. Patent No. 5,568,200) as allegedly rendering obvious the independent claims of applicants' invention (i.e., claims 1, 19, 23, 34 and 37). This conclusion and the characterizations of the teachings of Reininger et al., Astle and Pearlstein et al. are respectfully traversed and reconsideration thereof is requested.

Before discussing the claims at issue, applicants again wish to gratefully acknowledge the indication of allowable subject matter in dependent claims 3-6, 9, 29 and 30 if rewritten into independent form including all limitations of the base claim and any intervening claims. These claims have not been rewritten herein, however, since the independent claims from which they depend are believed to recite patentable subject matter for the reasons stated below.

In prior responses to Office Actions, applicants have sought to characterize the problem or environment which results in applicants' recited adaptive encoding. The pending independent claims recite that the adapting of the encoding includes adjusting at least one controllable parameter employed in the encoding of the a frame being non-intra encoded to disable motion estimation and limit motion compensation to minimize after decoding thereof, visually perceptible pulsation artifacts between still frames of a sequence of still frames. Thus, applicants reduce, or eliminate, pulsation artifacts from a sequence of still frames by disabling the motion estimation and limiting motion compensation during the encoding process when a still frame of the sequence is identified. Disabling motion estimation and limiting motion compensation encourages the skipping of the macroblocks in the still frame being non-intra encoded. By definition, a skipped macroblock is duplicated, without change, from a prior, reference picture.

In the present application, after determining that a frame is contained within a sequence of still frames, motion estimation is disabled to ensure that the motion estimation vector is zero, thereby allowing a reference frame versus current frame comparison to be performed on the same coordinates or placement within the frames. For example, if a current macroblock of a frame is located within a still frame at pixel row index 48 and pixel column index 64, the only comparison allowed will be at the same coordinates in the reference frame.

Further, motion compensation is limited in a still frame by allowing any difference value between the two macroblocks that fall below a predetermined threshold to be nullified or artificially set to zero. This allows macroblocks that would ordinarily fail the criteria for skipping to be skipped, thus reducing or eliminating the possible artifacts that would occur in normal compensated macroblocks due to lossy compression noise.

Neither Reininger, et al., Astle, nor Pearlstein et al., taken separately or together, teach or suggest applicants' above-noted process for artifact reduction when non-intra encoding frames with constant content from frame to frame (i.e., still frames contained within a still sequence of frames). Neither Reininger, et al., Astle, nor Pearlstein et al. address the disabling of motion estimation to guarantee zero valued motion vectors, nor does either patent discuss a threshold for

artificially nullifying macroblock differences and thus limiting motion compensation for the purpose of allowing more skipped macroblocks within a still frame during the non-intra encoding process.

The Office Action acknowledges that Reininger et al. do not appear to disclose the limitation of "minimize after decoding thereof, visually perceptive pulsation artifacts between still frames of a sequence of still frames". In furtherance of this statement, applicants respectfully submit that Reininger et al. do not discuss adaptively encoding a still frame to disable motion estimation and limit motion compensation while encoding the still frame. The Office Action cites the teachings of Astle to address the deficiencies of Reininger et al. Astle teaches low-pass filtering to eliminate block-edge artifacts, thus changing the values of some of the pixels themselves within the current picture. A careful reading of Astle fails to uncover any teaching, suggestion or implication of an adaptive encoding approach wherein motion estimation is disabled and motion compensation is limited when non-intra encoding a still frame of a sequence of still frames, let alone such adapting to minimize, after decoding thereof, visually perceptible pulsation artifacts between still frames of the sequence as recited by applicants in the independent claims presented herewith.

The Office Action acknowledges that Reininger et al. and Astle do not disclose applicants' characterization of the encoding process as "disabling motion estimation and limiting motion compensation" (let alone to minimize, after decoding thereof, visually perceptive pulsation artifacts between still frames of the sequence of frames). The Office Action cites the teachings of Pearlstein et al. to allegedly address the deficiency of Reininger et al. and Astle as applied against the independent claims presented. For example, the Office Action alleges that Pearlstein et al. teach:

> "... the disablement of motion compensation and limiting motion compensation (in col. 8, lines 41-58), Pearlstein discloses that the use of a refresh control processor which utilizes a refresh descriptor data for inhibiting frame display until an appropriate amount of non-erroneous image data develops for decoding; further, in col. 9, lines 6-19, Pearlstein discloses that until an appropriate amount of non-erroneous image data is constructed, the image data is refreshed meaning that previous image data is repetitiously sent until the complete reference frame is

constructed, thus, stopping motion estimation and limiting motion compensation until non-erroneous image data is constructed so as to display clear, high quality image data".

The above characterizations of the teachings of Pearlstein et al. and their alleged applicability to applicants' claims are respectfully, but most strenuously, traversed for multiple reasons. First, the Pearlstein et al. patent is principally directed to decoding processes, not encoding processes, as claimed by applicants. Second, there is no motion estimation or motion compensation process discussion in the Pearlstein et al. process, since again, Pearlstein et al. are principally discussing decoding, not encoding. Third, the image data discussed at columns 8 & 9 of Pearlstein et al. comprises the decoded pixel data. Again, one skilled in the art would understand that decoded pixel data would not have any motion estimation or motion compensation characteristics. Fourth, disabling the frame display does not equate to limiting motion estimation or motion compensation during the encoding process. Disabling frame display in Pearlstein et al. is intended to allow sufficient time to buffer pictures to be displayed after the decoding process. Demodulator 26 is employed after the decode process. Pearlstein et al. is directed to saving portions of a picture in order that there be sufficient data to display. Further, Pearlstein et al. discuss intra-coded portions of pictures. One skilled in the art would understand that an intra-coded picture has no motion estimation or motion compensation component to begin with. Intra-coded portions of pictures are encoded strictly with spatial redundancy only, not temporal redundancy. This is contrary to applicants' amended independent claims, which expressly recite disabling motion estimation and limiting motion compensation when the still frame is being non-intra encoded.

For all the above reasons, applicants respectfully submit that the independent claims presented patentably distinguish over the applied art, and request reconsideration and allowance of all claims.

In further support of applicants' position, certain content from applicants' prior response is repeated hereinbelow for the Examiner's ready convenience.

Applicants recite in the independent claims that the "still frame" and "still macroblock" comprise a frame and macroblock with certain content identical and unvarying to content of a preceding frame or a corresponding macroblock in a preceding frame. Thus, the phrase "sequence of still frames" as defined in the present application and used in the claims, is distinguishable from the interpretation given the phrase in the above-referenced Office Action. Applicants recognize as suggested by the Examiner that each frame in a sequence of frames is just that, a frame itself. However, the phrase "still frame" or "still macroblock" is used in the present application to mean that certain content of the frame does not vary from one frame to the next, i.e., that the content is fixed over a period of time such that a particular frame has little or no pixel difference with the frame preceding it. For example, a motionless test pattern depicted over a period of time so as to be represented by multiple frames would mean that there is a sequence of still frames such that any one frame contains content that is identical and unvarying to content of a preceding frame.

By way of further explanation, one specific definition of a "still frame" is an input frame to an encoder whose pixel data does not vary by either value or position with respect to the temporally previous frame input to the encoder. That is, frame i+1 contains identical pixel data to frame i for the entire frame. An example of such a still frame would be that the exact same picture is being fed into an encoder over a period of time.

As a further example, a partially still frame may comprise an object or objects within an input frame to an encoder whose pixel data does not vary by either value or position with respect to the same object or objects contained within a temporally previous frame input to the encoder. That is, frame i+1 contains identical pixel data for an object or objects contained within the frame to the identical object or objects contained within frame i. An example of a partially still frame would be a series of frames whose background is constant, say a tree or house, which does not move or change position, although an object or objects in the foreground may, such as a car driving by the house.

The meaning of "still frame" is significant to the present invention. The problem addressed by the present invention is the existence of "pulsation artifacts" which may occur after decoding of a series of encoded still frames. As used in the present application, "pulsation artifacts" is the result of encoding and decoding processes on successive frames having certain identical and unvarying content (i.e., still frames). Due to slight variations in the details in the encoded frames, visually apparent fluctuations in the decoded and displayed images may occur. These differences may give the impression of motion, and are known in the art as pulsation artifacts. Thus, while the initially received sequence of video frames may comprise a series of identical "still frames" in raw data format, after the still frames have undergone lossy compression and decompression (i.e., encoding and decoding) there may visually appear artifacts in the ultimately displayed image resulting from the lossy compression and decompression of the images. The present invention is directed to minimizing these artifacts with display of the ultimate image. Again, because of the compression techniques used, a video image that contains certain content identical and unvarying to certain content of the previous and/or next images may not be displayed identically after decompression of that image. Variations in, for example, luminance and/or chrominance data of the decoded images may falsely give the impression of movement of the identical content from one image to the next. This is also referred to in the application as "apparent" movement of the still pictures.

In accordance with applicants' invention, a determination is first made that a still frame in a sequence of still frames in a series of video frames has been received at the encoder. The independent claims further recite that a "still frame" comprises a frame with certain content identical and unvarying to certain content of a preceding frame. Thus, a sequence of still frames comprises a special case within a sequence of frames wherein there is no motion of certain content from one frame to the next. Applicants then adapt encoding of that still frame in order to minimize subsequently occurring visually perceptible pulsation artifacts between that still frame and an adjacent still frame after the frames have undergone encoding and decoding. The problem addressed by the present invention exists when a series of identical or nearly identical still frames are encoded and then decoded for display. When such frames are displayed, visually perceptible "pulsation artifacts" may occur. The present invention thus seeks to minimize these

pulsation artifacts which would otherwise occur after decoding of an encoded still frame by adjusting the at least one controllable parameter employed in the encoding of that still frame.

In comparison, Reininger et al. describe a multi-pass encode system which uses the number of bits produced from encoding a macroblock as feedback to change the quantizer used on the same macroblock in the same frame in a next encode pass. If the number of bits produced for a macroblock on a pass is greater than a threshold number, then the quantizer is changed for a next encode pass.

Initially, Applicants note that Reininger et al. do not address or discuss the same problem as that to which the present invention is directed. A careful reading of Reininger et al. fails to uncover any discussion of processing still frames as the term is defined and used in the present application, let alone recognizing the pulsation artifact problem addressed by Applicants, or Applicants claimed solution to the problem. Reininger et al. address the uniformity of image quality by limiting the amount of compressed data produced by the encoding process. Applicants' invention, however, is directed to minimizing visually perceptible pulsation artifacts occurring in a sequence of still frames which are displayed after undergoing encoding and decoding of the identical frames.

As used in the present application, a still frame is any frame in a series of received video frames that has certain identical and unvarying content to certain content in the previous and/or next frame such that the raw data frames contain at least partially visually identical information. Therefore, when the images are displayed, the visual appearance should remain constant from one frame to the next notwithstanding the encode and decode processing of the data which has occurred.

In contrast, Reininger et al. disclose a system for encoding video data which includes calculating the bits produced and encoded (i.e., compressed) for macroblocks within a single frame, and using this information as feedback for further refinements in the encode process.

Reininger et al. determine the number of bits produced for macroblocks within a frame, and if the size is too large, then the quantizer is changed for the subsequent encode pass. Essentially, Reininger et al. disclose a constant bit rate encode process which seeks to maintain picture quality without violating the constant bit rate. To accomplish this, Reininger et al. evaluate the same picture in compressed data format multiple times (see column 4, lines 3 et al.). Applicants respectfully submit that this process of Reininger et al. is substantially different from Applicants' recited processes.

The Office Action essentially mischaracterizes a still frame as an I-picture. This mischaracterization of the prior art and application thereof to the problem addressed by the present invention is respectfully traversed. Each of the independent claims presented herewith defines "still" as a frame or macroblock that has certain content identical and unvarying to certain content in the preceding frame or macroblock in a series of frames. Thus, the still frame or macroblock has minimal pixel difference from one frame to the next. It is the existence of such still frames which gives rise to the problem addressed by the present invention. Not every frame in a group of frames necessarily comprises a still frame as the phrase is defined in the independent claims presented herewith. Typically, there is content motion (i.e., change) from one frame to the next in a sequence of video frames. If there is content motion from one frame to a subsequent frame, the frames necessarily do not comprise still frames as defined in the present application.

In contrast to applicants' "still frame", an "I-picture" refers to a type of encoding performed by an encoding process on a frame. As is well known in the art, a frame can be encoded as an I, P or B frame. Thus, an I-picture or reference picture refers to a type of picture resulting from the encoding process. In the present application, the "still frame" comprises a frame characterization which is determined prior to the encoding process. As noted above, applicants' "still frame" refers to there being certain content identical and unvarying to certain content in the preceding frame. Once a still frame is identified, then in applicants' process the encoding is adapted to minimize after decoding of the encoded stream, visually perceptible pulsation artifacts between still frames of a sequence of still frames. Applicants' use of "still

frame" has nothing to do with the type of picture encoding employed for the frame. A still frame could be encoded as an I, P or B picture.

To summarize, Applicants are addressing a problem unique from that of Reininger et al. Specifically, Applicants seek to minimize visually perceptible pulsation artifacts which occur in a displayed video stream after the stream has undergone encoding and decoding processes, and in particular, which occur where the stream contains a series of still frames, i.e., frames with at least partial content which is identical and unvarying from frame to frame. Reininger et al. does not address or even discuss the existence of a series of still frames within a sequence of video frames, nor does the patent address the problem of visually perceptible pulsation artifacts occurring upon displaying a sequence of still frames which have undergone encode and decode processes. Applicants' invention comprises a technique for minimizing pulsation artifacts by adjusting the encode process of the frame as soon as the frame is identified to comprise a still frame. Applicants respectfully submit that a careful reading of Reininger et al. fails to uncover any teaching, suggestion or implication to one skilled in the art of such a technique.

The Office Action recognizes that Reininger et al. does not appear to disclose the limitation of "minimize after decoding thereof, visually perceptible pulsation artifacts between still frames of a sequence of still frames". However, the teachings of Astle are cited to address this deficiency. Specifically, the Office Action alleges that the "block edge artifacts" discussed in Astle equate to the "pulsation artifacts" defined by applicants in the independent claims presented herewith. The Examiner's use of "pulsation artifact" as a substitution for "block edge artifacts" in the Astle discussion is respectfully traversed.

As understood by one skilled in the art, the phrase "block edge artifacts", and the discussion of Astle, describe artifacts caused within a picture itself from difficulty in encoding pixels of different frequencies, for example, when transitioning from a black edge to a white space. In contrast to this artifact, applicants' "pulsation artifacts" are temporal artifacts caused by difference in compression ratios between two sequential pictures.

The phrase "pulsation artifacts" is understood in the art and defined in the present application to mean visually perceptible pulsations which may occur in a sequence of still content frames which have been displayed after undergoing encoding and decoding of the identical frames.

Additionally, a careful reading of Astle fails to uncover any teaching, suggestion or implication of a process for adapting encoding of a frame when the frame is a "still frame" as discussed above and defined in the independent claims presented herewith. Thus, applicants respectfully traverse the characterization in the Office Action that "... Astle discloses the illumination of the block edge artifacts (i.e., pulsation artifacts) after the decoding of a series of encoded still frames or images (Col. 6, lines 25-47)." There is no discussion or suggestion in the Astle patent that the individual frames that are being decoded are still frames having still content similar to the present application. The Office Action's characterization of the teachings of Astle as relating to decoding of a series of encoded still frames is without basis in the Astle patent, and therefore believed erroneous. There is no discussion in Astle of a still frame, nor is there discussion in Astle of a series of encoded still frames. Further, Astle is not even discussing an encoding process, but rather is addressing the decoding process. The Astle patent relates to a problem which is different from that of the present invention. In Astle, the problem of "block edge artifacts" is addressed by smoothing out a picture using blending techniques during the decoding process. For all the above reasons, the problem addressed by Astle, and the teachings thereof, are vastly different from applicants' recited invention.

Thus, applicants respectfully request reconsideration and withdrawal of the obviousness rejection to independent claims 1, 19, 23, 34 & 37 based upon the teachings of Reininger et al. in combination with Astle and Pearlstein et al. The dependent claims are believed allowable for the same reasons as the independent claims from which they depend, as well as for their own additional characterizations.

The claims are believed to be in condition for allowance and such action is respectfully requested.

Should the Examiner wish to discuss this case with applicants' attorney further, the Examiner is invited to contact applicants' attorney at the below-listed number.

Respectfully submitted,

Kevin P. Radigan

Kevin P. Radigan, Esq.
Attorney for Applicants
Registration No. 31,789

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HESLIN ROTHENBERG FARLEY & MESITI P.C.
5 Columbia Circle
Albany, New York 12203
Telephone: (518) 452-5600
Facsimile: (518) 452-5579